Fermilab HINS Program

2.5 MeV Beam Commissioning Plan

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Introduction

This document defines the commissioning plan for 2.5 MeV beam in Meson Detector Building as a part of the Fermilab HINS R&D program.

The objective of HINS 2.5 MeV beam commissioning is to verify the functionality of the HINS Radio Frequency Quadrupole (RFQ) as an accelerator, to make initial measurements of its output beam parameters, and to establish procedures and conditions for subsequent HINS 2.5 MeV beam operations.

Specifically and exclusively, the scope of activities described herein relates to commissioning a proton beam in the "initial HINS 2.5 MeV configuration" as referenced in letter from Dr. Joanna M. Livengood, DOE Fermilab Site Manager, to Dr. Bruce Chrisman, Fermilab COO, and dated April 27, 2009.

HINS 2.5 MeV beam commissioning activities shall, at all times, meet all applicable Fermilab FESHM and FRCM requirements and conditions stated in the Livengood letter, and shall abide by Accelerator Division beam operations practices.

HINS 2.5 MeV Beam Commissioning

Relevant Supporting Documents

- Beams-doc-3514- HINS Test Facility at Meson System Overview of Hazards
- Beams-doc-3505 - HINS MDB Ion Source Safety Documents

Configuration

Beams-doc-3514, "Fermilab HINS Program 2.5 MeV Beam - Design, Operations, and Safety Assessment" describes the "initial HINS 2.5 MeV configuration" that shall exist for 2.5 MeV beam commissioning. This configuration provides for beam acceleration through the HINS RFQ, transport through a diagnostic beam line and finally disposal into a suitably designed absorber terminating the diagnostic beam line.

2.5 MeV Beam Commissioning Plan

Conditions

All aspects of 2.5 MeV beam commissioning shall be subject to the following conditions for the duration of the commissioning activities:

1. All beam commissioning activities shall proceed only within limits approved by Accelerator Division Radiation Safety Officer or designee.

2. Radiation surveys shall be taken during commissioning to verify "that operation of the 2.5 MeV prototype does not create a radiological area…" (per Livengood/DOE letter).
3. At each iterative step in the commissioning process, RSO-designated personnel shall monitor for radiation and approve operating limits.
4. No configuration changes shall occur without prior discussion and concurrence of RSO.

Beam Control

Two "beam off" modes are specifically defined in Beams-doc-3514, "Fermilab HINS Program 2.5 MeV Beam - Design, Operations, and Safety Assessment":

1. *"Beam Shut Down" – This mode is established when the LEBT beam stops are fully inserted and the ion source high voltage supply is locked off.*
2. *"Beam Switch Off" – This mode is established when the relative timing of the ion source and RFQ RF pulses are set to not overlap in time.*

"Beam Switch Off" is the normal control for enabling and disabling beam during active commissioning operations.

"Beam Shut Down" is the required control state whenever qualified personnel are not present and actively pursuing commissioning activities.

Commissioning Plan:

1) After the HINS ion source and RFQ are physically mated together, and until approval to begin commissioning is received, the HINS ion source beam stop enable key shall be held by AD RSO.
2) Establish ion source beam up to beam stop with nominal LEBT solenoid setting and the following beam parameters:
    a. 50 keV energy
    b. 0.5 Hz repetition rate
    c. 0.5 millisecond pulse length
    d. 10 mA current measured at LEBT beam current transformer
3) With the LEBT beam stop closed, establish RF power in the RFQ with the following parameters:
    a. Ion source mistimed from RFQ by ~5 milliseconds
    b. 0.1 Hz repetition rate
    c. 50 microsecond pulse length
    d. 400kW peak pulsed power
    e. All 2.5 MeV beam diagnostic triggers set properly relative to RFQ timing
4) Verify that the manually operated beam line vacuum valve is open. <u>This must be verified each time beam operation is re-started during commissioning.</u>
5) In the presence of RSO-designated radiation monitoring personnel, proceed to open the ion source beam stop and set RFQ time coincident with ion source beam.

6) Tune LEBT solenoids, steering magnets, and RFQ power (not higher than 450 kW) to maximize beam transmission though RFQ as observed at diagnostic line BPMs and beam current transformer.
7) Measure beam profile with wire scanners in the diagnostic line to assure peak beam current density on the beam absorber does not exceed 0.013mA/mm^2.
8) Measure beam energy via time of flight measurements using signals from BPMs.
9) Iterate through steps 6, 7 and 8 while increasing beam current in ~5 mA increments up to 25 mA at exit of RFQ as the ion source permits.
10) For each 5mA beam current increase out of the RFQ, re-measure beam profile with wire scanner immediately upstream of the beam absorber. To avoid absorber damage, the peak pulsed beam current density on the absorber must not exceed 0.013 mA/mm^2.
11) Increase RFQ RF power pulse length to 100 microseconds and repeat steps 6 and 8 above.
12) Increase RFQ pulse rate to 0.5 Hz and repeat steps 6 and 8 above.
13) Reduce RFQ repetition rate to 0.1 Hz, increase ion source pulse length to 1.0 millisecond. Iterate RFQ RF power pulse length up to 1.0 millisecond in 0.1 millisecond increments, repeating steps 6 and 8 above.
14) Through each phase of iteration Radiation Safety personnel shall monitor for radiation and shall set operating limits for succeeding steps.

Definition of End of Commissioning

Achievement of all three of the following items defines completion of HINS 2.5 MeV beam commissioning:

1. Measurement of RFQ output beam energy at a beam current of ≥10mA
2. Operation of nominal 2.5 MeV beam for five consecutive minutes at 0.1 Hz pulse rate, 1ms pulse length and output beam current >10mA
3. Writing and approval, by HINS management and by AD ES&H management, of documents detailing the procedures and conditions for subsequent HINS 2.5 MeV beam operations